

Flange member comprising a first flanged end designed with a, in a radial direction, concave endsurface and a flange joint comprising flange members

The present invention relates to a flanged member intended to be included as a component in a pressure equipment device, as well as a joint comprising two  
5 joint halves in the form of two flanged members and included in a pressure equipment device, as is described in the preamble of claim 1 and claim 11, respectively.

It has been known for a long time to join different parts and components in pressure equipment devices, preferably pipe systems, by using flanged members.  
10 By flanged member, also called flange member or only flange, is here intended not just a pipe member, one end of which has been provided with a ring-shaped collar or flange, but also different components which may be included in a pipe system and that have at least one flanged end. It may, for instance, pertain to valves, Y-pieces or joint parts which may have one or more flanged ends for connection to  
15 other parts in the pipe system, vessels having a flange for the mounting of a lid, halves of casings for axial flow turbines or the like. The expression "flanged member" should, in this connection, also be regarded to comprise so-called blind flanges, i.e. an member that is used in order to close a pipe, by the fact that it is mounted on another flanged member in the pipe system or the like. A blind flange  
20 is frequently formed as a plate (without opening) that on one hand covers the pipe opening and on the other hand forms the flange, possibly with some type of an axially protruding portion.

So-called flanged joints comprise two flanged members that are closely joined, usually by means of bolts that are screwed through the opposite flange of  
25 the two flanged members and with prestress against nuts. Also other types of joining devices may be used, e.g. clips or clamps.

Flanged joints may generally be provided with sealing members or lack sealing members. Sealing members that transfer forces from a flange to another flange are usually denominated gaskets. Sealing members that do not transfer any  
30 significant forces from a flange to another and which enable metal-to-metal contact between the flanges are usually denominated seals. The present invention relates in particular to flanged joints without gasket and which enable metal-to-metal contact, with or without seal.

Flanged joints and other joints where flanged members are included are used in numerous applications, and the dimensions of the pipes and members that are included may vary substantially. As examples of applications, may be mentioned within the offshore industry, sub sea industry, process industry, 5 petrochemical industry, in power plants, in oil and gas transport pipes, on tankers, etc. The flanged joints and flanged members that are constructed according to conventional technique, with gaskets, and that are used here, are very heavy, space-demanding and expensive. It is given that reliability of the flanged joints as for function and in particular leak tightness has to be guaranteed, since breakdown 10 may cause loss of human life as well as extensive environmental damage and production loss. However, there is in principle always a certain leakage in dismountable flanged joints designed according to conventional technique, and in those cases when fixed welded joints are used instead, a more difficult maintenance and exchange is obtained in return.

15 Thus, insufficient leak tightness and leakage is among the largest problems as for flanged joints. There may be many reasons for this. A general problem for all types of flanged members and flanged joints is the stresses and loads that arise in the material at the assembly of the flanged ends on the members. In many cases, these also lead to a deformation of the flange, which in 20 turn risks causing deteriorated tightness and problems with leakage. At flanged members where a non-flanged end is welded onto a pipe, which is commonly occurring, frequently these deformations arise as a consequence of the generation of heat during the welding. A known way to try to decrease these problems with stresses in the material is to form the transition between the flange on the flanged 25 end of the member and the non-flanged end as a substantially elliptical area. This known technique is disclosed, for instance, in US-A-4,183,562 and in WO-A-93/17268.

It is general for all types of flanged joints that in many cases the fact is that the leakage does not arise until after a period of time. This may be due to, e.g., 30 alternating loads and high stresses in combination with thermal loads and vibrations. In many flanged joints, there is also a dynamic condition, which entails that the sealing surfaces become worn and that bolts loose their prestress or cracks as a result of fatigue. Corrosion may also contribute to leakage arising.

A way of trying to cope with these problems of leakage is to form the end surfaces directed towards each other, of two flanged members, so that they are inclined, thereby, in radial cross-section, forming an angle to each other, when they have been brought together but before assembly, so that the distance  
5 between the two end surfaces increases in radial direction outwards. Such a solution is also known by said document WO-A-93/17268. However, this leads to an uneven deformation of the end surfaces, which does not provide a good seal. In said document, it is also disclosed how the end surfaces may have part surfaces that are "conical", something which also results in an uneven deformation  
10 and poor seal.

It has also turned out that a flanged joint, having end surfaces that abut sealingly against each other after tightening of the bolts or the like of the joint, still starts to leak due to the fact that it is deformed when the system in which it is included is pressurised by the fact that a fluid begins to flow through the system.  
15 Said deformation depends foremost on the pressure in the pipe system, the properties of the material in the flange as well as the dimensions thereof.

The deformation that arises in the end surfaces, for various reasons, some of which have been mentioned above, most often means that they do not preserve their flatness, but even becomes slightly convex, i.e. bulge outwards. In the  
20 simplest case, they become slightly convex already in connection with the bolts being tightened and then foremost around the boltholes, when it is a bolted joint. This results in the innermost contact point between the end surfaces being displaced somewhat outwards in the radial direction, so that no sealing abutment is obtained between the end surfaces farthest in towards the opening of the  
25 flanged member. It is the understanding about this problem that is the basis of the present invention.

Moreover, it is also a fact that it is very difficult on the whole to manufacture flanged members having a satisfying flatness on the end surfaces.

An additional reason for insufficient leak tightness, above all after a period  
30 of time, is that sealing members, in particular gaskets, age and lose their function.

In this connection, it should be emphasised that the reliability of flanged joints in respect of leak tightness is of primary importance. Also a deteriorated leak tightness that results in a very small leakage may, for instance, constitute a

serious hazard when it is environment-negative, unhealthy or flammable materials that are transported in the pipe system.

Thus, the object of the present invention is to provide a solution to the mentioned problems. This is attained by a flanged member as is defined in the characterizing part of claim 1, as well as by a joint as is defined in the characterizing part of claim 11.

Thus, by the present invention, is proposed a flanged member that is intended to be included as a component in a flanged joint, for installation in a pressure equipment device and having a first flanged end with a first end surface intended to be assembled together with a second end surface of a flanged end on another, second flanged member constituting a second component in said flanged joint, which is characterized in that said first end surface is slightly concave in the radial direction over at least a part of the extension thereof in the radial direction. With the expression "concave" is meant that, at a cross-section through the flanged end, the end surface is limited by a curve being a concave function. The end surface is in other words slightly curved so that it curves or bulges inwards.

By allowing that the end surface becomes slightly concave already at the manufacture, first of all the problem with making it entirely plane is avoided. If you fail ever so little with the flatness, the risk following therewith is also avoided of the end surface instead becoming somewhat convex, which is a large disadvantage as has been explained above. By making the end surface slightly concave, you accordingly put yourself on "the safe side" of the straight line representing the flatness.

At tightening and pressurizing of the joint in which the flanged member is included, the slightly concave or inwardly curving/hollow end surface will be somewhat deformed so that it becomes almost plane. In any case, it will not become convex and it will be possible to retain the highest surface pressure of the end surfaces farthest in at the opening of the flanged member, which is a condition for good leak tightness.

This is particularly important at flanged joints without seal or gasket. In such flanged joints, there are contact surfaces in the form of said end surfaces, which also should work as satisfactory sealing surfaces. Since this is about metal to metal contact, extra high requirements are made on the surfaces so that a satisfactory tightness should be attained. Thus, by means of the present invention,

the possibilities are improved of using non-gasketed and seal-free joints and yet achieve a satisfactory tightness. Since gaskets and seals are made from material that age, as has been mentioned above, these types of joints are frequently subjected to leakage after a certain time of use. Therefore, it is a major advantage to instead be able to use non-gasketed and seal-free joints, with a metal-to-metal contact, which give a satisfactory seal. Such joints also have the advantage of having a low weight and less need for space in comparison with conventional technique, in addition to high reliability. Thus, the advantage is obtained of lower initial and operation costs.

10 As an example of the high leak tightness that is attained with the present invention, it may be mentioned that at tests with joints comprising flanged members according to the invention, leakage that is extremely low has been measured, of the order of 1 g He/500 yrs.

Preferably, the end surface is concave over the entire extension thereof in the radial direction. However, it is feasible to limit the concavity to an area being that which essentially will be subjected to deforming forces when the flanged member is assembled together with another flanged members as well as during use, i.e. pressurizing of the system where the member is included. Particularly at flanged members having very large dimensions, it may be appropriate to only let a part of the radial extension of the end surface be concave. However, in most cases, the concavity begins already farthest in at the opening of the flanged member.

Alternatively, said first end surface is concave in the radial direction over essentially the area that, during use (i.e. pressurizing of the system where the member is included, see above), is foreseen to constitute contact surface against the corresponding end surface of said second flanged member.

According to another alternative, said first end surface comprises more than one concave part surface in the radial direction and said part surfaces may have different radii of curvature.

30. According to an advantageous feature, the flanged member has an internal, through, axial opening and said first end surface has an innermost abutment point against the corresponding end surface of said second flanged member, which abutment point is situated farthest in in the radial direction, at said

opening, and that the concavity of the first end surface extends all the way in to said abutment point.

According to an alternative embodiment, suitable for a blind flange, the flanged member is characterized in that said first end surface has an innermost  
5 abutment point against the corresponding end surface of said second flanged member, which has an internal, through, axial opening, and that said innermost abutment point is situated farthest in in the radial direction, at said opening, and that the concavity of the first end surface extends all the way in to said abutment point.

10 The concavity is suitably very slight. Thus, the flanged member is characterized in that a conceived straight line X that connects the innermost point a of the first surface, in the radial direction, with the outermost point b thereof, in the radial direction, has a length Lx and that the concavity of the end surface has a maximum depth Dk in relation to a conceived plane surface produced by said line  
15 X, which depth Dk is of the order of 0,01 %–2 % of Lx. Preferably, the depth Dk is of the order of 0,01 %–0,2 % of Lx. The mentioned interval of Dk is approximate since it also depends on the pressure in the pipe system, the properties of the material in the flange and the dimensions thereof in other respects.

The joint that is proposed according to the present invention comprises  
20 two joint halves in the form of two flanged members included in a pressure equipment device, which members have at least one flanged end each having an end surface, and which members are put together via their end surfaces of said flanges, which surfaces are facing each other, characterized in that at least one of said flanged members, and preferably both, is designed according to any one of  
25 claims 1–10.

Thus, by the present invention, the advantage is obtained of a flanged member that in unloaded state is compensated for the deformation it is foreseen to be subject to when it is in a loaded state. Thus, also in the loaded state, you have a flanged joint that has sealing surfaces abutting against each other with metal to  
30 metal contact, all the way in to the fluid pressure, i.e. all the way in to the edge closest to the opening. Consequently, the joint is tight.

Additional advantages and features will be apparent from the remaining dependent claims.

The invention will now be described more in detail, reference being made to an embodiment example, illustrated schematically in the accompanying drawings, in which:

Fig. 1 shows a schematic side view, in cross-section, of a joint according to the present invention, and

Fig. 2 shows a schematic side view, in cross-section, of a part of a flanged member according to the present invention, and on an enlarged scale.

The joint shown in figure 1 comprises two flanged members 1, 2, each having a first end 3, 4 provided with a collar or flange 5, 6, as well as a second non-flanged end 7, 8. The flanged end 3, 4 of the respective flanged members has an end surface 10, 11 that in this case also is a contact surface, i.e. a surface intended to abut against a corresponding surface of the opposite flanged member, after assembly. The flanges 5, 6 extend preferably 360° and are provided with through borings 13, 14. At joining, the flanges are bolted together to a joint by means of bolts that are inserted through said borings. Usually, there are a number of borings arranged evenly distributed around the flange. All through the flanged members, a tubular duct 15, 16 extend. Here, the transition area 17, 18 between the flange and the non-flanged end consist of an elliptically shaped area. The illustrated joint is a non-gasketed and seal-free joint.

The end surfaces 10, 11 of the flanged members facing each other are somewhat chamfered or inclined so that they, in radial cross-section, form an angle to each other, when they have been brought together but before assembly, so that the distance between the two end surfaces increases in the radial direction outwards, which is seen in fig. 1. After the assembly, which in the illustrated joint is made by a bolt being inserted into each pair of borings 13, 14 and tightened, the end surfaces 10, 11 will abut against each other.

In fig. 2, a flanged member 1 included in the joint in fig. 1 is shown schematically and in enlargement. The flanged member 1 has an end surface 10 having a concave shape in the radial direction. The concavity in the schematic illustration is strongly exaggerated, as is the chamfering/inclination of the end surface. The concavity is in effect very small and would, at a depiction according to scale of a flange having the illustrated proportions, not be seen at all. For this reason, here it has been necessary to strongly exaggerate the concavity of the shown end surface and also the inclination. It should also be pointed out that with

the expression "the extension of the end surface in the radial direction", is intended throughout this application also the extension that an end surface has that is slightly inclined or sloping and that accordingly is not entirely perpendicular to the centre axis C of the member.

5           The end surface 10 has an internal, through, axial opening 15. It has an innermost abutment point a against the corresponding end surface of said second flanged member (not shown), which innermost abutment point is situated farthest in in the radial direction, at said opening. It has also a corresponding outermost abutment point b against the corresponding end surface of said second flanged  
10 member, which outermost abutment point is situated farthest out in the radial direction. Said abutment points are connected with a conceived straight line X, having a length  $L_x$ .

          The concavity of the end surface has a maximum depth  $D_k$  in relation to a conceived plane surface produced by the same line X, which depth  $D_k$  is of the  
15 order of 0,01 %–2 % of  $L_x$ , and preferably 0,01 %–0,2 % of  $L_x$ .

          Of course, it is preferable that both of the flanged members in a joint have concave end surfaces, but it would also be feasible that only one of the members has a concave end surface.

          In the illustrated preferred embodiment example, the concavity extends all  
20 over the end surface in the radial direction. However, it would also be feasible that this was not the case, e.g. at flanged members where the flange has very large dimensions. However, the end surface should be concave in the radial direction over at least an area that essentially equals the area that will be subjected to a deforming force when the flanged member in question is assembled together with  
25 a second flanged member included in the joint, as well as during use.

          The present invention is not limited to the illustrated embodiment example but may be varied and modified in a variety of ways by a person skilled in the art, within the scope of the accompanying claims. Particularly, it should be pointed out that the invention is not limited to the illustrated embodiment example, but may, for  
30 instance, have a non-elliptical transition area, a non-inclined end surface, or be provided with seal, e.g. in the form of a seal ring in a groove. The end surface in the illustrated example is a concave surface having only one radius of curvature, but could also be a concave surface composed of a plurality of radii of curvature. It

is of course also feasible to apply the invention to inwardly turned flanges, i.e. flanges that are turned inwards in the pipe system.

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